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DOE/RL-94-131
Draft A

# Letter Report for Skyshine Abatement Assessment



United States
Department of Energy
Richland, Washington

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# Letter Report for Skyshine Abatement Assessment

Date Published

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United States
Department of Energy
P.O. Box 550
Richland, Washington 99352

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## FIGURES

## ACRONYMS

| | |
|---|---|
| ALARA | As Low As Reasonably Achievable |
| DOE | U.S. Department of Energy |
| DOE/RL | U.S. Department of Energy, Richland Operations Office |
| FCGG | Federal Geodetic Control Committee |
| LWDF | Liquid Waste Disposal Facilities |
| MEI | maximally exposed individual |
| PNL | Pacific Northwest Laboratory |
| R | Roentgen |
| RCRA | Resource Conservation and Recovery Act |
| TLD | thermoluminescent dosimeter |
| WHC | Westinghouse Hanford Company |

# EXECUTIVE SUMMARY

The term skyshine, as used in this report, refers to radiation originating from the 1301-N/1325-N Liquid Waste Disposal Facilities (LWDF) and reflecting back to the surrounding 100 N Area. Skyshine was first observed in 1980 by 100 N Area operators who were able to correlate elevated radiation readings with the amount of water shielding over 1301-N (i.e., depth of water maintained over 1301-N). Since 1980, measures have been taken to hold the errant radiation in abeyance. The most prominent of those measures are the concrete panels that currently reside atop 1301-N and 1325-N.

This letter report has been issued in support of the overall 100 N Area strategy to address whether the effects of skyshine adversely impact the public who may pass near 1301-N/1325-N or those who trespass upon the area, in the course of traveling along the Columbia River or its southeastern bank near the 100 N Area. The most likely trespasser are those who may fish or camp on the 100 N Area shoreline. Although the public is legally prohibited from occupying the shoreline it is possible that the public could physically gain access to the 100 N Area shoreline. In response to this concern, Tri-Party Agreement milestone M-16-12 was established. This report addresses whether abatement of skyshine is necessary to protect the general public prior to implementing the *1301-N/1325-N Closure Plan/Corrective Measure.*

Exposures to workers in the 100 N Area are being addressed through numerous other channels, such as Hanford Site safety procedures and the *1301-N/1325-N Closure Plan/Corrective Measure Study.* As a part of the overall Hanford Site cleanup activities, the 100 N Area has undergone extensive studies. The 1301-N/1325-N units are currently being addressed under the Tri-Party Agreement and are subject to *Resource Conservation and Recovery Act (RCRA)* action. A characterization effort (limited field investigation and qualitative risk assessment) is planned for 1301-N/1325-N, in support of the Tri-Party Agreement milestone M-15-12A. The information from this project will be incorporated into the *1301-N/1325-N Closure Plan/Corrective Measure Study* in support of the Tri-Party Agreement milestone M-15-12B. This report addresses only the exposures to the public, who may trespass on the 100 N Area shoreline, that may potentially result from the 1301-N/1325-N skyshine. In order to address the exposure to the public, the following questions have been addressed in this report:

- To what degree is the public subjected to the adverse effects of skyshine?
- If warranted, what sort of abatement action would be justified?

The U.S. Department of Energy (DOE) has set a limit on the amount of radiation the general public may receive in one year in DOE Order 5400.5 at 100 mrem/yr. This limit has been utilized in this report to determine if remedial actions to abate skyshine are necessary to protect the public. In pursuing the public exposure issue, 100 N Area monitoring data were evaluated. In addition, public exposure opportunities along the 100 N Area shoreline were identified and evaluated. In the final analysis, the following conclusion was reached:

> Individuals from the public would not receive a dose above the annual 100 mrem/yr DOE limit from the 100 N Area skyshine.

If an abatement action is deemed unnecessary by DOE prior to implementation of the *1302-N/1325-N Closure Plan/Corrective Measure Study*, then continuing institutional controls offer the most cost effective and implementable option to continue protecting the public from skyshine. If additional action is deemed necessary, covering the source with shielding material would be the most effective temporary alternative.

# 1.0 PROJECT BACKGROUND

The term skyshine refers to ionizing energy (radiation) that emanates from radiation sources and showers down (from the sky to the ground) upon the 100 N Area at the Hanford Site, in southeast Washington. Radiation emanating upwards from a ground-level source is "scattered" or "reflected" off of oxygen, hydrogen, nitrogen and other atoms in the atmosphere. A significant portion of this air-scattered radiation returns to the earth. This phenomenon is commonly referred to as "skyshine."

Preliminary studies indicate that two Hanford Site waste management units (1301-N and 1325-N) are the primary sources of skyshine (Westinghouse Hanford Company [WHC] 1994a). The units were designed to receive radioactive effluent originating in the N Reactor building. The effluents originate from the primary reactor coolant system, periphery reactor cooling systems, decontamination of these systems, and drainage from reactor support facilities (DOE 1993a). The 1301-N and 1325-N trenches are described as being long with waste management cribs at the wastewater inlet. The trenches of 1301-N and 1325-N have the following nominal dimensions. 1301-N measures 30 m wide; 630 m long; and 5 m deep. 1325-N measures 40 m wide; 1100 m long; and 2 m deep (see Figure 1). Radiation levels as high as 1 R/hour have been detected within 1 m above the concrete panel located at the portion of the crib that is closest to the inlet pipe to 1301-N.

During the period from 1962 until 1987, it was standard practice at the Hanford Site to discharge radioisotope-contaminated effluent into the cribs and associated extension trenches, allowing for percolation into the surrounding soil. At that time, percolation was an accepted practice for waste disposal. It was through the discharge and leaching process that the surrounding soil became contaminated with radioactivity. The trenches were primarily overflow units that received wastes containing lower concentrations of radioisotope-contaminated effluent than the cribs because the cribs are located next to the wastewater inlet. As a result of the discharges, the materials that occupy 1301-N and 1325-N act as sources of ionizing radiation believed to be the cause of skyshine in that area. The area includes portions of the Columbia River shoreline that are in close proximity to 1301-N and 1325-N. It is expected that the highest concentrations of residual waste will be located within and immediately adjacent to the cribs (especially near the wastewater inlet), with diminishing concentrations of radioisotope-contaminated soil found near the trench tailwater extremities. Cobalt ($^{60}Co$) and Cesium ($^{137}Cs$), the major contributing radioactive isotopes in the units, have half lives of 5.26 yr and 30.17 yr, respectively (DOE 1993a).

# 2.0 PROJECT DESCRIPTION

In recent years there has been increased interest in learning whether skyshine has an adverse impact to the public who may pass by the 1301-N and 1325-N areas in the course of traveling along the Columbia River or its southeastern bank. In response to this "public exposure" question, Tri-Party Agreement milestone M-16-12 was established.

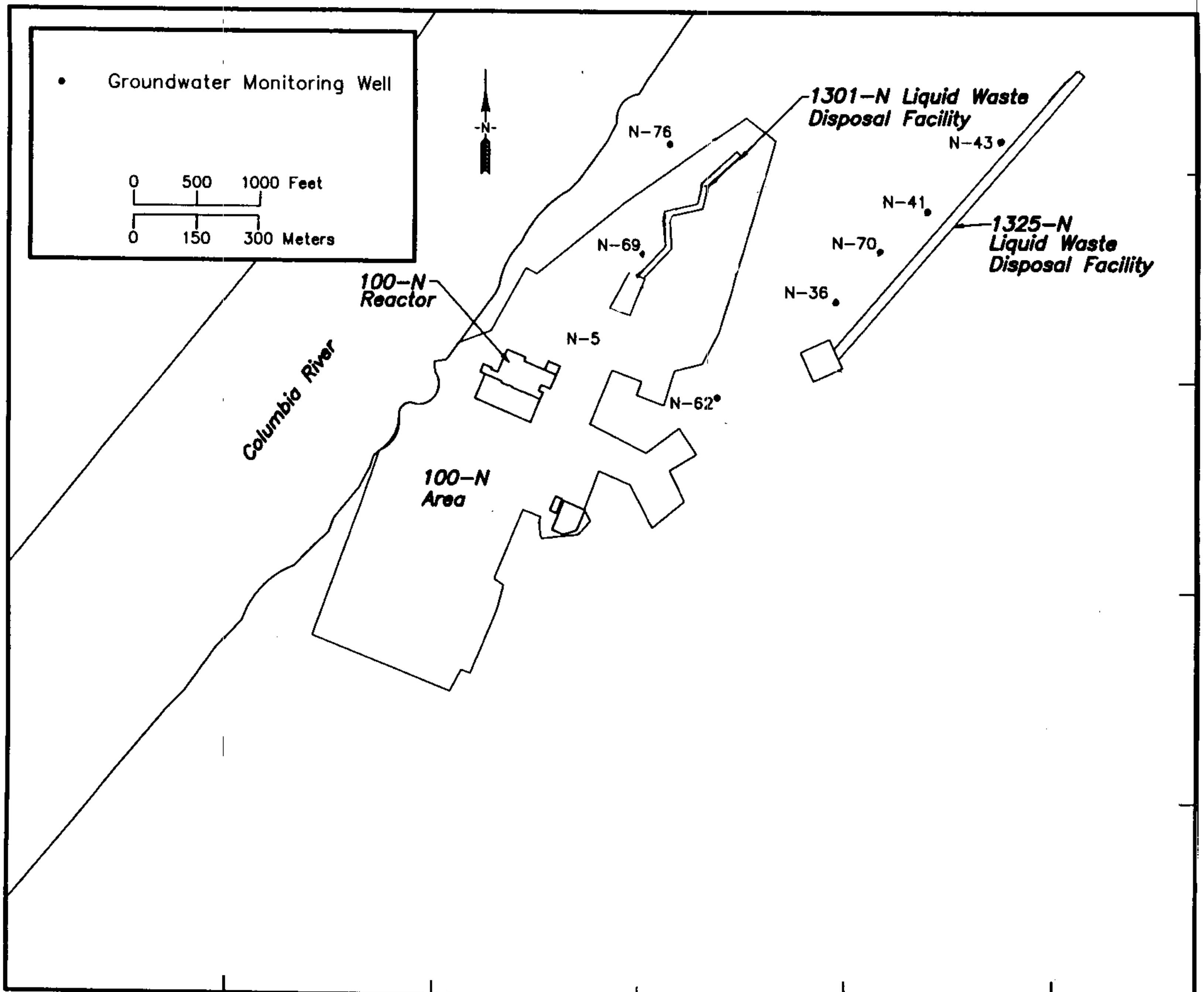



Figure 1. Site Map.

In order to satisfy the terms of the milestone the following questions must be addressed in the form of a report:

1) To what degree is the public subjected to the adverse effects of skyshine?

2) If warranted, what form of abatement action would be justified?

To answer these questions, potential public exposures to skyshine and two alternatives addressing skyshine were evaluated. This report does not make a recommendation of the best alternative. Instead, it provides the DOE Richland Operations Office (RL) with sufficient information to determine if skyshine abatement is required to protect the public prior to the implementation of the *1301-N/1325-N Closure Plan/Corrective Measure Study*.

# 3.0 100 N AREA RADIATION EXPOSURE RATES

## 3.1 Review of Radiation Exposure Rate Data

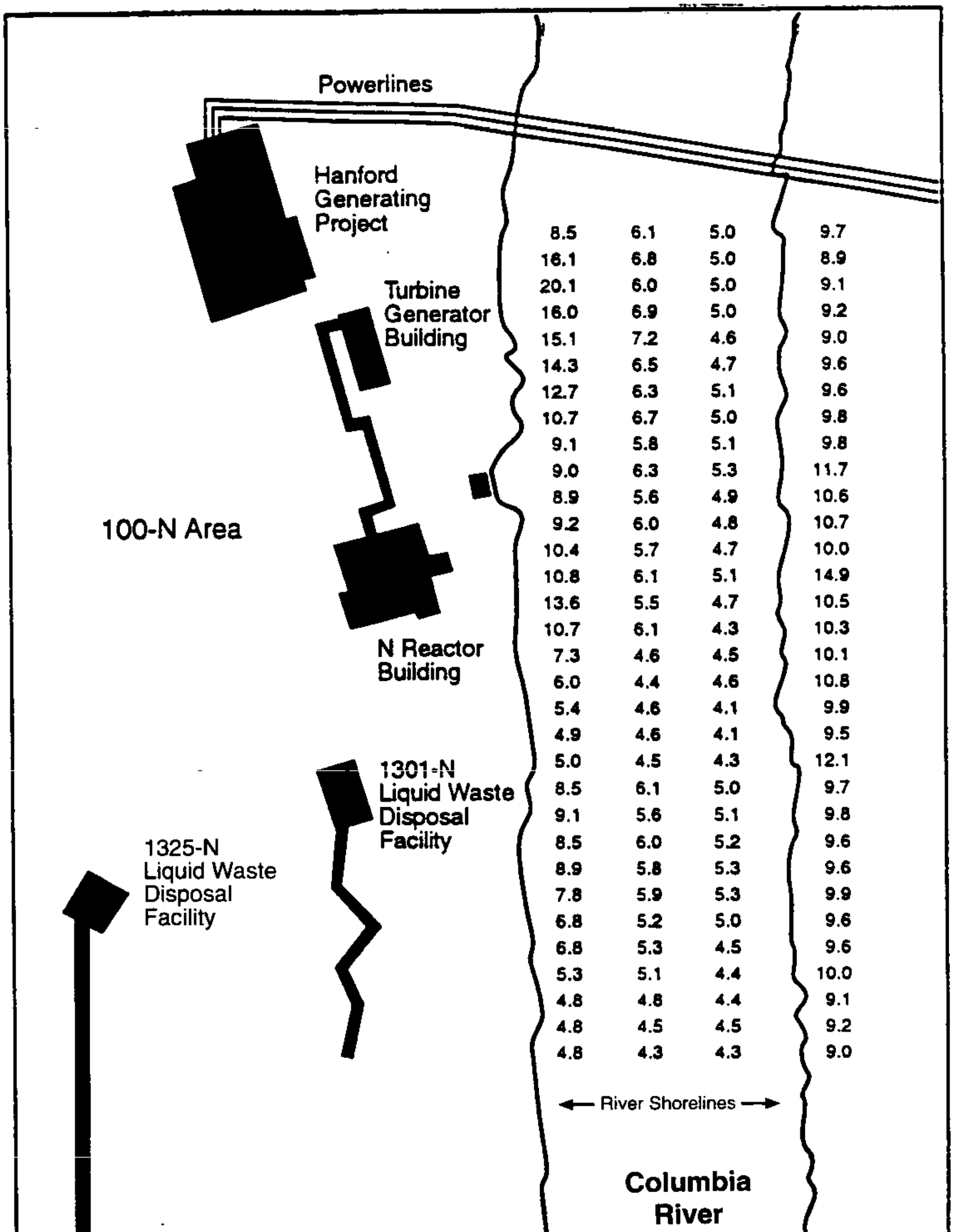
### 3.1.1 Summary of Data

Several sources provide radiation exposure rate information about the skyshine areas of concern in 100 N. These include the *Hanford Site Environmental Report* (Pacific Northwest Laboratory [PNL] 1994), the *Environmental Monitoring Annual Report* (WHC 1994b), the *Investigation of Exposure Rates and Radionuclide and Trace Metal Distribution Along the Hanford Reach of the Columbia River* (PNL 1993), and the *Transmittal of Radiation Exposure Rate Survey* (WCB 1994).

Figure 2 illustrates the 128 locations of hand-held instrument (micro-R meters) measurements adjacent to the 100 N Area (PNL 1993). Figure 3 illustrates similar reading locations obtained along the 100 N Area shoreline (PNL 1994). In Figure 2, the readings near the 100 N Area are highest next to the 100 N Area shoreline, and then decrease in the Columbia River. On the opposite side of the Columbia River the readings increase again. The readings decrease in the Columbia River because the river is further away from the cribs than the shoreline, and the river does not have background terrestrial radiation. All of these radiation levels are, however, influenced by radiation sources in the Hanford Site 100 N Area. This is evidenced by increases in the exposure rates directly opposite the N Reactor and the 1301-N/1325-N, as compared to measurement values from other locations.

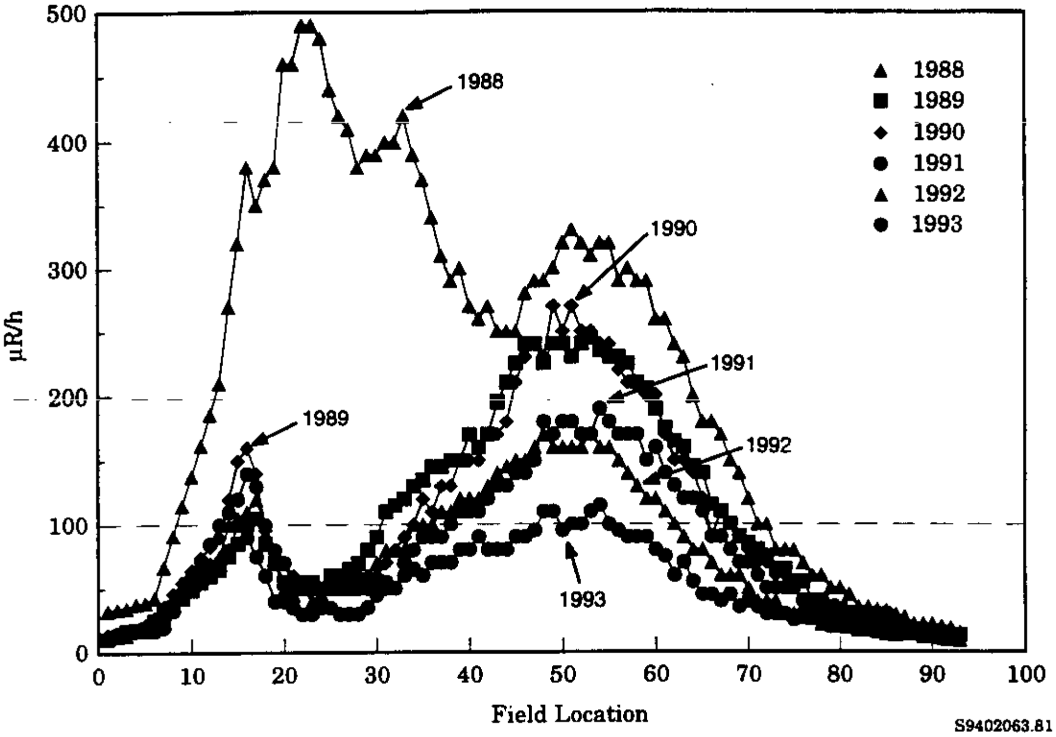
Readings obtained at similar Columbia River shoreline locations, but distant from the 100 N Area, were in the range of 3.5 to 4.5 $\mu$R/hr (PNL 1993), representing an approximation of a location-specific micro-R meter background. The values shown in Figures 2 and 3 include this location-specific background. Subtracting an average background value of 4 $\mu$R/hr from the readings obtained over the river and opposite shoreline, and prorating these readings to annual values, the average is 30 mrem/yr, with minimum and maximum values of 3 mrem/yr and 150 mrem/yr, respectively. Figure 3 also shows radiation levels decreasing over time.

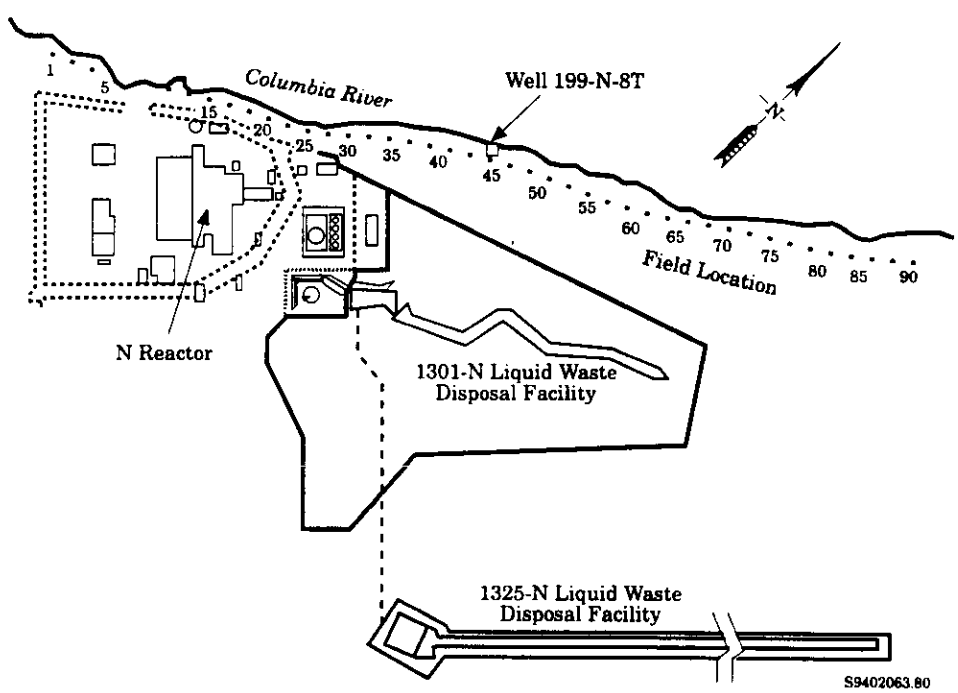
Figure 2. Exposure Rates on the Columbia River Adjacent to the 100 N Area (μR/hr).




Source: Modified from PNL 1993

**Figure 3. Radiation Measurements Along the 100 N Area Shoreline.**




Source: Modified from PNL 1994

Figure 4 shows the four locations of thermoluminescent dosimeter (TLD) monitoring locations used by PNL for environmental monitoring purposes in the 100 N Area (PNL 1994). A total of 13 measurements were obtained from the aggregate of these locations during calendar year 1993. The annualized average for these measurements was 197 mrem/yr, with a corresponding maximum value of 256 mrem/yr.

Westinghouse Hanford Company utilizes one TLD monitoring location in the same general area as PNL (see Location Number 26 in Figure 5). The average of four measurements made at this location during calendar 1993 was reported as 210 mrem/yr (WHC 1994b), with a corresponding maximum value of 250 mrem/yr.

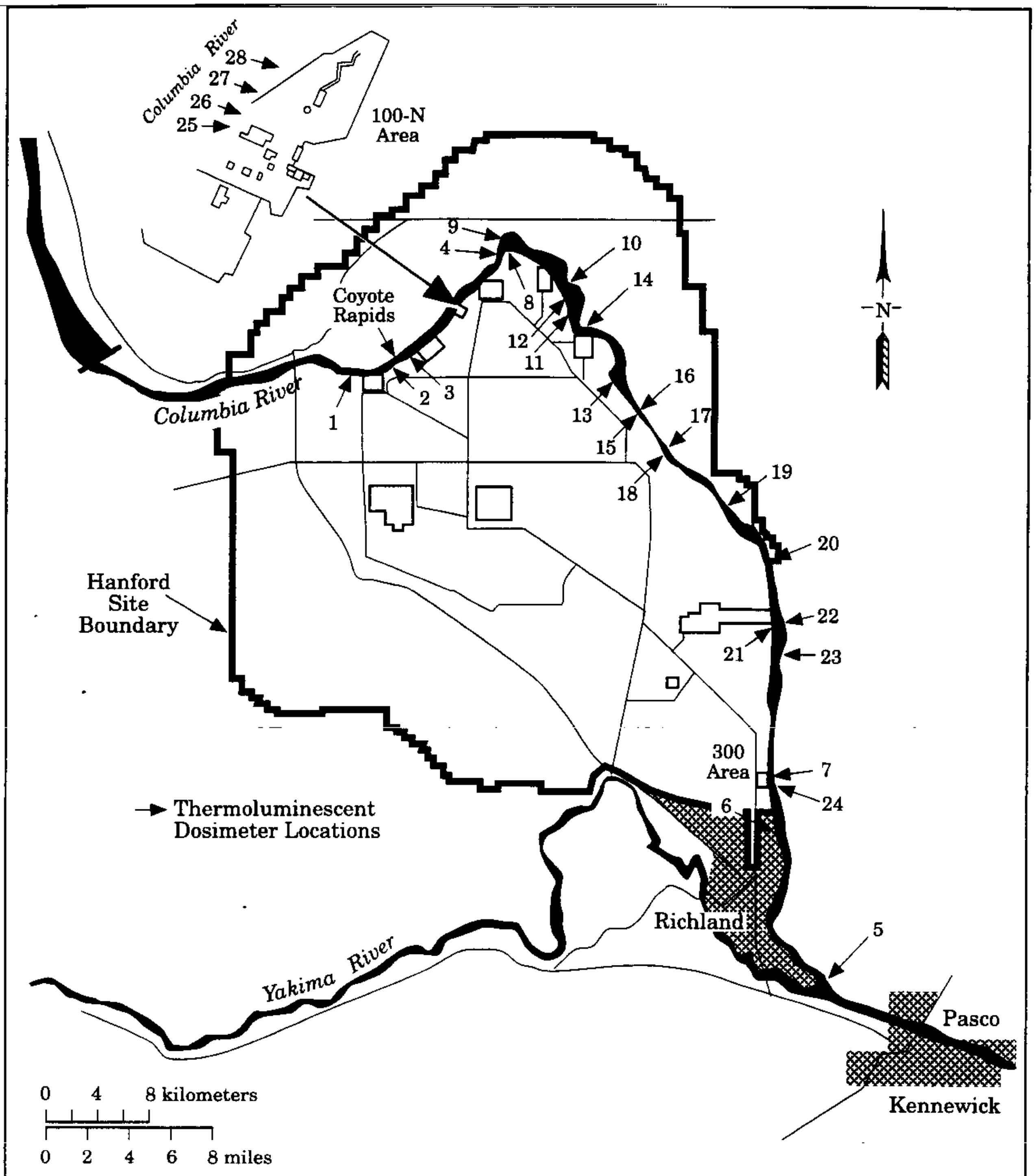
A special micro-R meter survey (WCB 1994) conducted along the 100 N shoreline for comparison to the instrument readings obtained by PNL (PNL 1993 and PNL 1994) indicated values ranging from 10 $\mu$R/hr to 30 $\mu$R/hr. As with the PNL data, these readings include background. Subtracting the same 4 $\mu$R/hr background value, the corresponding annualized values become 88 mrem/yr and 228 mrem/yr, respectively.

In addition to the direct radiation exposures resulting from skyshine, the Columbia River is routinely sampled for those radioactive materials most likely to appear in liquid effluent. Concentrations of the radioactive materials in the river are reported in both the *Hanford Site Environmental Report* (PNL 1994) and the *Environmental Monitoring Annual Report* (WHC 1994b). Data from the *Hanford Site Environmental Report* provide concentrations of radionuclides in the Columbia River, while the *Environmental Monitoring Annual Report* provides concentrations of radionuclides in discharges to the Columbia River. Figure 6, taken from the *Hanford Site Environmental Report*, illustrates concentrations of radionuclides along the 100 N Area shoreline in 1993. Only the tritium results (~29,000 pCi/L) are of significance. All other radionuclide concentrations are less than 5 pCi/L, in their aggregate (exclusive of the 5.1 pCi/L total activity from the gross alpha and gross beta measurements). The gross alpha/beta measurements are not radionuclide specific, and will consequently be discounted for the purposes of this report.

### 3.1.2 Data Analysis

TLD data are more accurate and precise than hand-held instrument readings. This is because hand-held instrument readings are difficult to repeat, in that placing the instrument in precisely the same location year after year is subject to error. Conversely, TLD stations are designed to ensure that each TLD device remains in precisely the same location throughout the measurement period. In addition, most hand-held instrument responses are dependent on the energy of the radiation being measured, which tends to over-estimate actual exposure rates, whereas TLD devices are relatively energy-independent. Finally, TLD devices measure radiation exposures constantly for the period of time they exist in the monitoring station (generally a calendar quarter), whereas hand-held instruments usually provide readings that are less than an hour (often times, less than 5 minutes) in duration. This means that the TLD data represent a truly integrated exposure rate, which is thereby more representative of the actual exposure rates than those recorded from hand-held instruments.

**Figure 4. Thermoluminescent Dosimeter (TLD) Locations and Station Numbers Established by PNL on the Hanford Reach of the Columbia River.**




Source: PNL 1993

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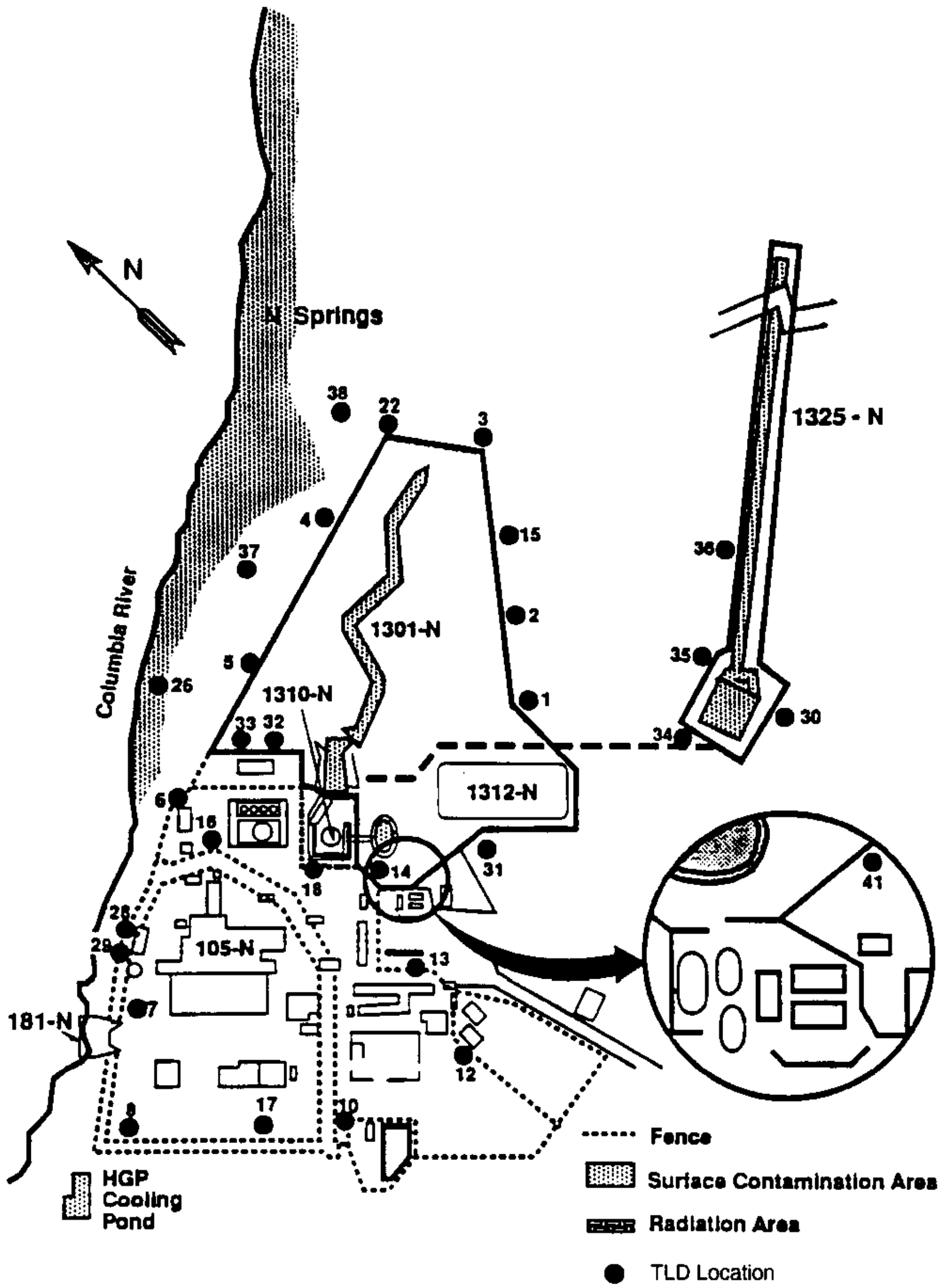
Figure 5. Thermoluminescent Dosimeter Locations (TLD) in the 100 N Area.




Source: WHC 1994

Figure 6. Radionuclide Concentrations Measured in Riverbank Spring Water During 1993.

| Radionuclide | No. of Samples | Concentration,[a] pCi/L Maximum | Average |
|---|---|---|---|
| **100-B Area** | | | |
| Alpha | 2 | 3.5 ± 1.6 | 2.3 ± 2.4 |
| Beta | 2 | 8.7 ± 3.0 | 8.2 ± 1.0 |
| $^{3}H$ | 2 | 12,900 ± 230 | 12,000 ± 1,900 |
| $^{60}Co$ | 2 | -0.2 ± 1.3 | -0.5 ± 0.6 |
| $^{90}Sr$ | 2 | <0.07 ± 0.10 | 0.04 ± 0.07 |
| $^{99}Tc$ | 2 | 23.5 ± 0.6 | 15.9 ± 15.1 |
| U-Total | 2 | 2.0 ± 0.1 | 1.8 ± 0.3 |
| **100-K Area** | | | |
| Alpha | 2 | 1.6 ± 1.2 | 1.5 ± 0.3 |
| Beta | 2 | 3.6 ± 2.5 | 3.2 ± 0.9 |
| $^{3}H$ | 2 | 18,300 ± 270 | 18,100 ± 500 |
| $^{60}Co$ | 2 | 0.8 ± 0.6 | 0.7 ± 0.2 |
| $^{90}Sr$ | 2 | 0.1 ± 0.1 | 0.04 ± 0.14 |
| $^{99}Tc$ | 2 | 0.8 ± 0.1 | 0.6 ± 0.4 |
| U-Total | 2 | 2.3 ± 0.1 | 2.2 ± 0.1 |
| **100-N Area** | | | |
| Alpha | 2 | 1.7 ± 0.9 | 1.6 ± 0.2 |
| Beta | 2 | 4.5 ± 3.1 | 3.5 ± 2.1 |
| $^{3}H$ | 2 | 28,900 ± 470 | 28,700 ± 400 |
| $^{60}Co$ | 2 | 1.5 ± 3.7 | -2.2 ± 7.3 |
| $^{90}Sr$ | 2 | 0.02 ± 0.25 | 0.005 ± 0.031 |
| $^{99}Tc$ | 2 | 2.1 ± 0.6 | 2.0 ± 0.2 |
| U-Total | 2 | 0.77 ± 0.09 | 0.71 ± 0.12 |
| **100-D Area** | | | |
| Alpha | 2 | 1.3 ± 1.1 | 1.3 ± 0.1 |
| Beta | 2 | 9.4 ± 2.9 | 9.2 ± 0.5 |
| $^{3}H$ | 2 | 6,530 ± 170 | 6,530 ± 10 |
| $^{60}Co$ | 2 | 0.5 ± 1.0 | -0.2 ± 1.4 |
| $^{90}Sr$ | 2 | 4.4 ± 0.4 | 4.4 ± 0.1 |
| $^{99}Tc$ | 2 | 0.08 ± 0.10 | -0.08 ± 0.32 |
| U-Total | 2 | 1.4 ± 0.1 | 1.3 ± 0.3 |
| **100-H Area** | | | |
| Alpha | 2 | 4.4 ± 1.8 | 3.8 ± 1.1 |
| Beta | 2 | 63 ± 6 | 62 ± 3 |
| $^{3}H$ | 2 | 1,190 ± 100 | 1,160 ± 60 |
| $^{60}Co$ | 2 | -0.07 ± 1.35 | -0.23 ± 0.31 |
| $^{90}Sr$ | 2 | 18.6 ± 0.6 | 17.9 ± 1.4 |
| $^{99}Tc$ | 2 | 133 ± 1 | 123 ± 21 |
| U-Total | 2 | 6.6 ± 0.2 | 6.1 ± 0.9 |
| **Old Hanford Townsite** | | | |
| Alpha | 2 | 4.0 ± 1.4 | 2.6 ± 2.9 |
| Beta | 2 | <95 ± 135 | 63 ± 63 |
| $^{3}H$ | 2 | 159,000 ± 1,200 | 142,000 ± 34,000 |
| $^{60}Co$ | 2 | 9.7 ± 9.4 | 5.4 ± 8.5 |
| $^{90}Sr$ | 2 | <-0.2 ± 0.2 | -2.8 ± 5.2 |
| $^{99}Tc$ | 2 | 131 ± 2 | 121 ± 20 |
| $^{129}I$ | 1 | 0.21 ± 0.01 | |
| U-Total | 2 | 4.3 ± 0.2 | 3.5 ± 1.6 |
| **300 Area** | | | |
| Alpha | 2 | 54.5 ± 6.2 | 33.6 ± 41.8 |
| Beta | 2 | 19.4 ± 3.6 | 11.4 ± 16.1 |
| $^{3}H$ | 2 | 9,850 ± 200 | 5,560 ± 8,590 |
| $^{60}Co$ | 2 | <0.3 ± 1.3 | 0.06 ± 0.53 |
| $^{90}Sr$ | 2 | <0.15 ± 0.17 | 0.13 ± 0.03 |
| $^{99}Tc$ | 2 | 9.3 ± 0.2 | 4.9 ± 8.8 |
| $^{129}I$ | 1 | 0.0019 ± 0.0002 | |
| U-Total | 2 | 104 ± 1 | 64 ± 80 |

(a) Maximum values are ±2 sigma counting error. Averages are ±2 times the standard error of the mean.

Source: PNL 1994

As a consequence, only TLD data will be used in the exposure assessments presented in this report. Hand-held instrument readings, however, do serve to illustrate that the maximum radiation exposure rates occur along the 100 N Area shoreline, and not on the river, or on the opposite shore of the river. This can be seen through comparison of the shoreline instrument readings to instrument readings obtained on the river and opposite shoreline (see Figures 2 and 3). This comparison is effective without background subtraction, or any treatment of the hand-held instrument data for their energy dependence. It can be concluded, therefore, that the maximum direct radiation exposure scenario for the public would involve occupancy on the shoreline along the 100 N Area.

Another significant observation of the hand-held instrument data presented in the *Hanford Site Environmental Report for Calendar Year 1993* (PNL 1994) is the reduction over time of the exposure rates along the Columbia River 100 N Area shoreline.

This effect is illustrated in Figure 3 for the five year period from 1988 through 1993. This effect is most pronounced in the area delineated by field measurement locations 40 through 70. These measurement locations are opposite 1301-N/1325-N. An examination of this phenomenon (utilizing TLD data) indicates that the combination of radionuclides producing the skyshine are decaying, with an effective half-life of 6.6 years (see Figure 7). The exposure rates measured during calendar 2000 would, therefore, be expected to be 50 percent (one-half) of the 1993 values.

## 3.2 Exposure Assessment

### 3.2.1 Expansion of the Data

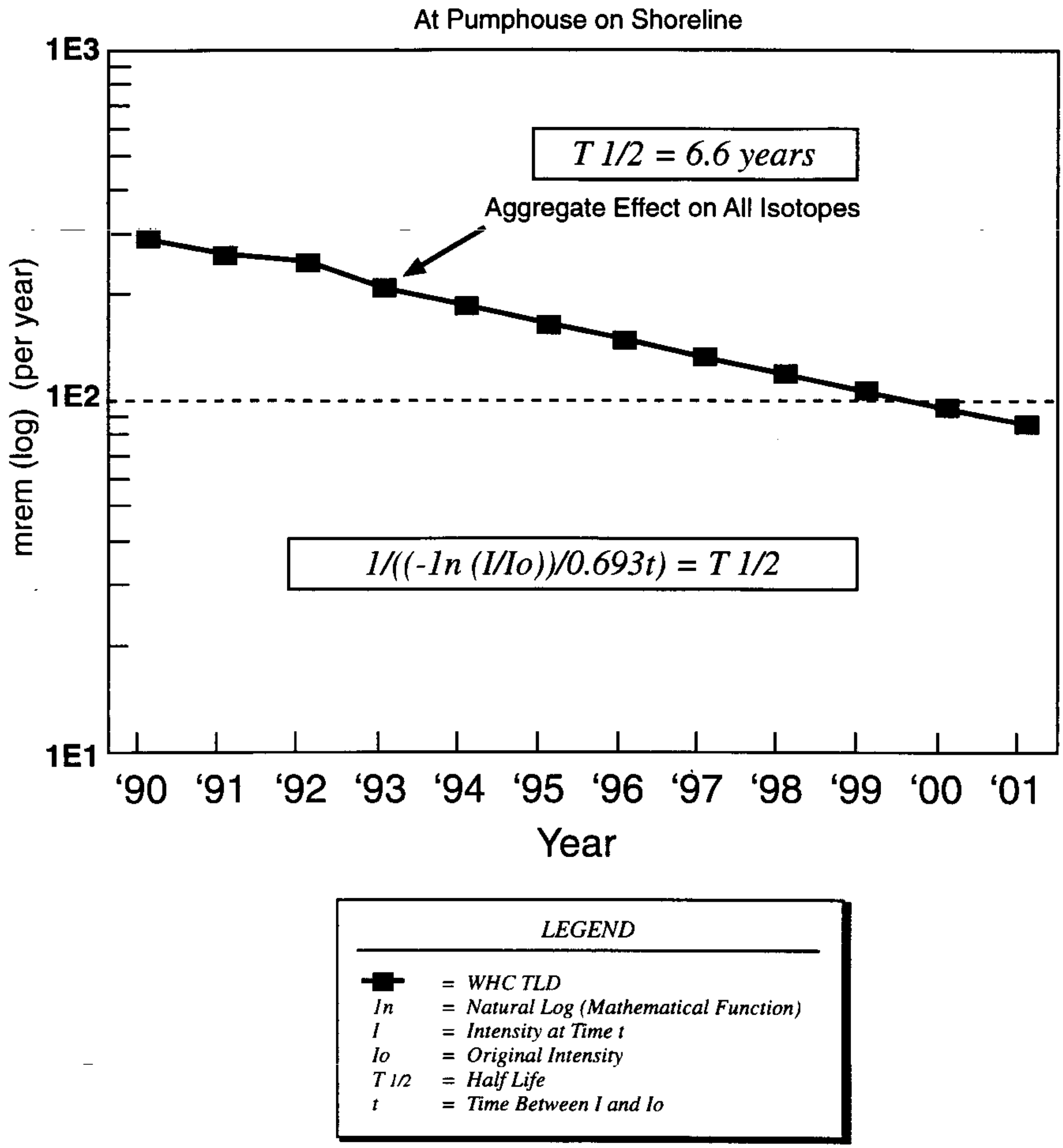
Although entry is legally prohibited, the general public can physically gain access to the shoreline along the Hanford Site 100 Areas, and in particular to the flowage easement lands adjacent to the 100 N Area. The flowage easement includes that area bounded by the Columbia River's waterline and the high-water mark on the shoreline (WHC 1991). The flowage easement (which will be referred to as the area of concern) is accessible only by boat or by swimming. Most recreational activities [e.g., swimming, skin- or scuba diving, water skiing, and certain fishing styles (e.g., trolling)] would involve physical movement in and out of the area of concern. Only fishing from or camping on the shoreline could reasonably be construed as activities that would result in occupancy.

As a consequence, the following exposure scenarios focus on only those activities that would result from a shoreline fishing or camping scenario. Because of the legal prohibition against occupancy of the 100 N Area shoreline, the occupancy scenarios are considered to result from trespassing.

- Scenario 1: 8,760 Hours

  This is the maximum number of hours, serving only as a baseline scenario.

Figure 7. N-Springs Skyshine Decay Estimate.



- Scenario 2: 3,096 Hours

  This is the maximum number of hours that a member of the general public could occupy the area of concern during the 129 day fishing season, at a rate of 24 hours per day.

- Scenario 3: 2,920 Hours

  This is the maximum number of hours that a member of the general public could occupy the area, at a rate of eight hours per day for the entire year.

- Scenario 4: 1,032 Hours

  This is the maximum number of hours that a member of the general public could occupy the area, at a rate of eight hours per day during the 129-day fishing season.

- Scenario 5: 888 Hours

  This is the maximum number of hours that a member of the general public could occupy the area of concern, at a rate of 24 hours per day for each weekend day during fishing season (a total of 37 weekend days).

- Scenario 6: 296 Hours

  This is the maximum number of hours that a member of the general public could occupy the area of concern, at a rate of eight hours per day for each weekend during the fishing season.

### 3.2.2 Indirect Exposure Assessment

In addition to exposure to direct radiation as a result of occupancy in the area of concern, an individual could theoretically be exposed by drinking water from the river, eating fish taken from the river, eating sediments from the bottom of the river, or swimming in the river. Each of these scenarios was examined by PNL (PNL 1994) for the "maximally exposed individual" (MEI), and for the sportsman who eats game (including fish). In their aggregate, these exposure scenarios represent an annual dose of less than 0.2 mrem/yr. Although of little significance, a value of 1.0 mrem/yr has been incorporated in the Figure 8 presentation of radiation exposures for the various occupancy scenarios one through six.

The Figure 8 assessment uses data that have not been corrected for background radiation. The reason for the uncorrected results is that PNL reports a significant variation in the direct radiation background exposure rate. According to PNL (PNL 1994), the direct radiation background rate varies from 88 mrem/yr (~10 μrem/yr) for locations outside the 100 N Area, to 100 mrem/yr (~11.4 μrem/yr) for locations along the perimeter of the Hanford Site. Figure 9 corrects the calculated exposures provided in Figure 8 for both direct radiation background rates (88 and 100 mrem/yr). The PNL TLD data were used in Figure 9, rather than the WHC data. This is because of the number of PNL stations (four

Figure 8. Comparison of Radiation Exposures to a 100 N Shoreline Trespasser.[1]

| EXPOSURE SCENARIO | OCCUPANCY TIME (hr/yr) | PNL TLD DATA | | WHC TLD DATA | |
|---|---|---|---|---|---|
| | | AVERAGE 197 (mrem/yr) | MAXIMUM 256 (mrem/yr) | AVERAGE 210 (mrem/yr) | MAXIMUM 250 (mrem/yr) |
| 1 | 8,760 | 198 | 257 | 211 | 251 |
| 2 | 3,096 | 71 | 91 | 75 | 89 |
| 3 | 2,920 | 67 | 86 | 71 | 84 |
| 4 | 1,032 | 24 | 31 | 26 | 30 |
| 5 | 888 | 21 | 27 | 22 | 26 |
| 6 | 296 | 8 | 10 | 8 | 9 |

1. Annualized doses include 1.0 mrem/yr from other exposure pathways.
TLD = Thermoluminescent Dosimeter

Figure 9. Comparison of Radiation Exposures to a Trespasser[1], Corrected for Background Exposure Rate.

| | | 88 mrem/yr BACKGROUND | | 100 mrem/yr BACKGROUND | |
|---|---|---|---|---|---|
| | | AVERAGE | MAXIMUM | AVERAGE | MAXIMUM |
| EXPOSURE SCENARIO | OCCUPANCY TIME (hr/yr) | 197 (mrem/yr) | 256 (mrem/yr) | 197 (mrem/yr) | 256 (mrem/yr) |
| 1 | 8,760 | 110 | 169 | 98 | 157 |
| 2 | 3,096 | 40 | 60 | 35 | 56 |
| 3 | 2,920 | 37 | 57 | 33 | 53 |
| 4 | 1,032 | 14 | 21 | 12 | 19 |
| 5 | 888 | 12 | 18 | 11 | 17 |
| 6 | 296 | 5 | 7 | 4 | 6 |

1. Annualized doses include 1.0 mrem/yr from other exposure pathways.

stations versus one WHC station), and because of the fact that, of the two sets of data, PNL reported the highest maximum value. As can be seen in Figure 9, the background corrected data indicate that exposures to a trespasser would be less than the DOE limit for public exposure of 100 mrem/yr for all exposure scenarios, if the direct radiation background is used.

The exposures in Figure 9 range from a low of 4 mrem/yr to a maximum of 169 mrem/yr for continuous occupancy at the highest exposure point on the near shoreline. Because access to the area of concern is limited to the Columbia River, and because access is prohibited by law, it is not reasonable to assume continuous occupancy. Such occupancy would be noticed by maintenance or environmental sampling personnel, if not by Hanford Site security forces (e.g., institutional controls within a calendar quarter). Making the assumption that a trespasser would be identified and removed within a calendar quarter, the resultant maximum radiation exposure would not exceed 43 mrem ([149 mrem/yr + 1.0 mrem/yr] ÷ 4 quarters/yr). This value (43 mrem) is well under the DOE operational limit of 100 mrem/yr (DOE 1994, DOE 1993). The more likely scenario would involve more casual access to the area of concern, as delineated in scenarios 5 and 6. Both of these scenarios produce estimated radiation exposures of less than 25 mrem/yr.

## 3.3 Interpretation of the Data

The foregoing discussion indicates that existing institutional controls are sufficient to limit the exposure of an trespasser attempting to continuously occupy the 100 N Area shoreline to less than the DOE limit of 100 mrem/yr. The chances that existing institutional controls would identify and remove the trespasser are proportional to the amount of time the intruder occupies the 100 N Area shoreline. In other words, the longer an intruder remains, the more likely he or she is to be identified and removed. Only scenarios 5 and 6 limit occupancy to the weekends. The weekend is the time period least likely for area visits by maintenance or environmental sampling personnel. As a consequence, these two occupancy scenarios represent the most likely exposure scenarios. Using average exposure rate data for these two scenarios results in a dose to the trespasser of less than 25 mrem/yr.

## 3.4 Potential for Impacting the Public

Exposure rates which occur in the 100 N Area decrease from the Columbia River shoreline toward the centerline of the river itself. Additionally, in-place institutional controls prohibit continual occupancy (8,760 hours per year) of the shoreline. Given these two facts, it is virtually impossible for any member of the public to receive an exposure in excess of the DOE limit for public exposure (100 mrem/yr). The two most reasonable exposure scenarios consider weekend camps on the shoreline during the fishing season, which result in radiation exposures of less than 25 mrem/yr. All exposure scenarios, and the resultant doses, include contributions from other pathways (e.g., immersion, ingestion, etc.). Using average exposure rate data for these two scenarios results in an annual dose to the trespasser of less than 25 mrem/yr.

# 4.0 SKYSHINE ABATEMENT ALTERNATIVES

The following two alternatives are evaluated in Sections 5.0 and 6.0:

1) Perform no additional action and allow the radionuclides in 1301-N and 1325-N to decay.

2) Cover the cribs and trenches with a shielding material to reduce the exposure rate.

An additional alternative targeting source removal was not evaluated because this remediation effort would subject remediation workers to excessive radioactive exposures. In 1993 and 1994, exposure rate readings indicate as much as 1 R/hr within 1 m above the concrete surface of the 1301-N crib. Exposures to 100 N Area workers is being addressed in the *1301-N/1325-N Closure Plan/Corrective Measure Study*.

The alternatives presented in Sections 5.0 and 6.0 were evaluated in terms of effectiveness, implementability, and cost. An alternative is considered effective in protecting the public when exposure levels are below the 100 mrem/yr limit. Both alternatives in Sections 5.0 and 6.0 are equally effective in this regard because current limits are met; however, the cover alternative will further reduce skyshine radiation levels. The implementability of an alternative is evaluated in terms of whether the alternative is easy to implement and the resulting exposure to remediation workers during implementation.

# 5.0 NO ACTION ALTERNATIVE

## 5.1 No Action Alternative Definition

Radiation emanating from 1301-N and 1325-N is believed to be the primary source of skyshine along the shoreline of the Columbia River at the 100 N Area. The no action alternative involves continuing access restrictions to 1301-N/1325-N, continuing the *1301-N/1325-N Closure Plan/Corrective Measures Study*, and maintaining the existing radiation monitoring program.

## 5.2 Advantages Associated with No Action Alternative

Except for costs incurred through execution of ongoing custodial maintenance of 1301-N/1325-N, there would be no other significant expenditures until closure of the cribs was engaged. In addition, remediation workers would not be subject to excessive radiation exposures, since no action would occur near the cribs/trenches.

## 5.3 Disadvantages Associated with No Action Alternative

The disadvantage of the no action alternative is that current radiation levels in the 100 N Area are not abated. However, both physical and administrative controls limit access to areas producing the elevated exposure rates. Personnel radiation exposure monitoring data indicate that these controls are effective in limiting 100 N Area personnel exposures to acceptable levels.

# 6.0 COVER ALTERNATIVE

## 6.1 Cover Alternative Description

The cover alterative involves placing cover material over 1301-N and 1325-N to shield the radioactive material. In addition, ongoing radiation monitoring program, access restrictions, and *1301/1325 Closure Plan/Corrective Measure Study* would continue.

## 6.2 Comparison of Materials Used to Achieve the Cover Alternative

### 6.2.1 Project Criteria

In order to identify preferred materials to be selected for the cover, the following three criteria were selected:

1) **Effectiveness:** This criterion evaluates whether the alternative is effective at maintaining the exposure limit below 100 mrem/yr.

2) **Implementability:** This criterion evaluates ease of placement and convenience of shielding cover removal. This criterion also includes a discussion on the risk to remediation workers placing the cover atop the cribs/trenches.

3) **Project Cost:** This criterion evaluates cost effectiveness.

### 6.2.2 Shielding Media Eligible for Consideration

1) Original Spoil. Spoil includes material that remains near the 1301-N and 1325-N units. This material would be placed back into the excavations from which the spoil came.

2) Pit Run Gravel, obtained from other Hanford Site sources and subsequently trucked to the 1301-N and 1325-N units.

3) Concrete Panels, fabricated onsite, would be rigged and crane-placed over the 1301-N and 1325-N units.

4) Thixotropic Mud (a form of Bentonite) would be delivered to the Hanford Site in rail cars, transferred to pneumatic tank trailers, and educted into the trenches pneumatically. After placement of the mud, a 1-ft-thick layer of native soil would be placed immediately above the thixotropic mud to prevent the mud from blowing away via aggressive local wind currents.

A computer program was utilized to determine the shielding thicknesses required for fill materials. The results are as follows: to reduce from the present reading of 1 R/hr down to 100 mrem/hr, use 24 in. of pit run gravel or original spoil; 17 in. of concrete; 32 in. of thixotropic mud; 5.6 in. of steel plate; or 39 in. of water.

**6.2.3 Shielding Media Ineligible for Consideration**

1) A re-engagement of the water blanket was dismissed as a possibility because of the following two considerations:

   a. Flooding the 1301-N and 1325-N units with water would mobilize radioactive contamination, thereby producing a "new" waste stream.

   b. Once produced, the "new" waste stream would migrate downward into the groundwater which, by definition, would constitute an "uncontrolled release."

2) Sheet Steel available from recycling operations was considered impractical for the following reasons:

   a. The thickness of steel required (5.6 in.) would create a static load of 250 $lb/ft^2$ on top of the existing concrete panels, surpassing the design stress for the panel structure, which is 56 $lb/ft^2$.

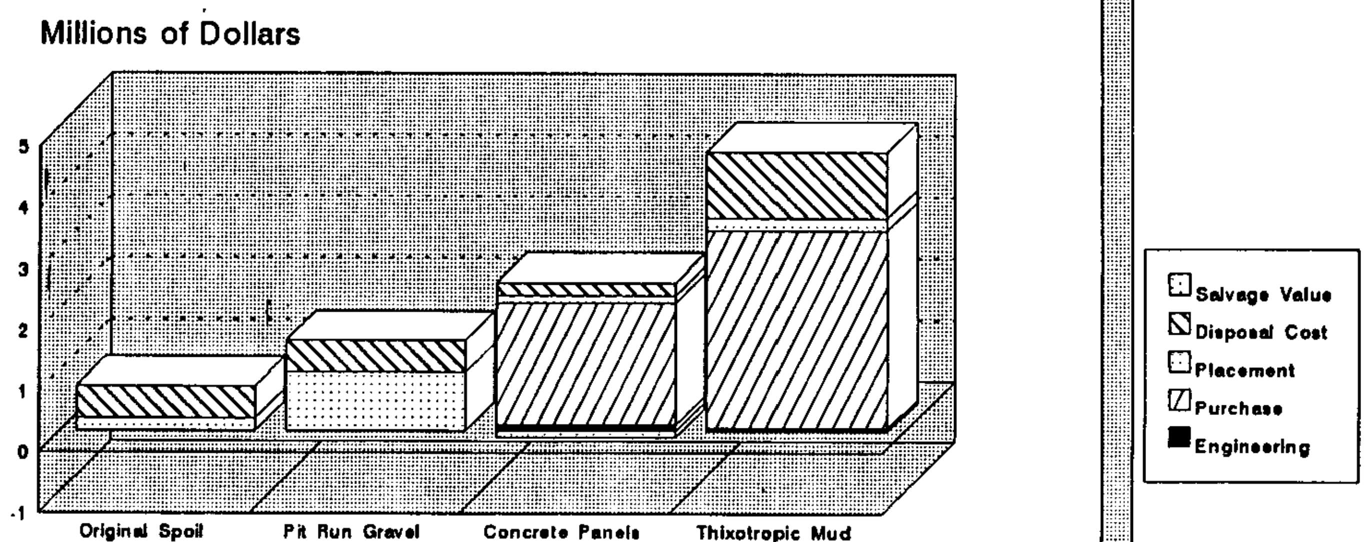
   b. Multiple handling and placement activities (e.g., the placement of 5 layers of 1.1-in.-thick plate steel) would introduce increased opportunities for industrial accidents and radiological exposure.

## 6.3 Assumptions for Cover Alternative Cost Estimate

Figure 10 presents estimated remediation costs.

Costs used in developing the comparison estimates were uniformly applied. Therefore, any variations in actual numbers had no impact on visible differences among the four options. Operating labor, equipment operation, equipment rental, and materials were included in determining cost comparisons. Other comparison factors are as follows:

- Purchased-material costs shown in Figure 10 were taken directly from vendor quotes. Equipment operating costs were developed from equipment hours required to perform the work.




| | Original Spoil | Pit Run Gravel | Concrete Panels | Thixotropic Mud |
|---|---|---|---|---|
| Salvage Value | 0 | 0 | -0.1 | 0 |
| Disposal Cost | 0.531 | 0.531 | 0.217 | 1.1 |
| Placement | 0.2 | 0.96 | 0.118 | 0.2 |
| Purchase | 0 | 0 | 2 | 3.22 |
| Engineering | 0.005 | 0.005 | 0.1 | 0.05 |

Costs Associated with Each Alternative

Figure 10. Remediation Costs for 1301-N/1325-N.

- Labor costs are for operating labor only, and reflect Hanford Site bargaining unit rates (with fringes).

- The cost to remove the cover once the *1301-N/1325-N Closure Plan/Corrective Measure Study* is implemented has been included in remediation costs. This cost was shown to indicate that, if mud was placed on the cribs/trenches, it would be twice as costly to remove than if spoil was used.

- All equipment was assumed to be rented on a monthly basis, and equipment productivity was developed according to the type of material to be handled. Hourly equipment operating costs were taken from a cost comparison guide for construction equipment (Dataquest 1993).

- Average productive hours per shift were assumed to be 5.25 hour.

## 6.4 Assumptions for Cover Alternative Time Estimates

Figure 11 presents the estimated time comparison for various cover materials. The following assumptions were used in developing Figure 11:

- Times used in developing the comparison estimates were uniformly applied. Therefore, any variations in actual numbers used had no impact on visible differences among the options.

- Design time is directly proportional to number and kind of materials, as well as unit operations involved in each considered alternative.

- Procurement time is directly proportional to number and kind of materials, as well as unit operations involved in each considered alternative.

- Construction times are directly linked to the number and kind of materials used, as well as unit operations engaged.

## 6.5 Assumptions for Cover Alternative Industrial Accident Potential

Figure 12 presents the remediation estimated industrial accident potential comparison (including radiological exposure potential). The following assumptions were used in developing Figure 12.

- Estimates were uniformly applied to determine the potential for accidents occurring during cover placements. Therefore, any variations in actual numbers utilized had no impact on visible differences among the four options. Accident potential units were developed for the design phase, procurement phase, and construction phase.

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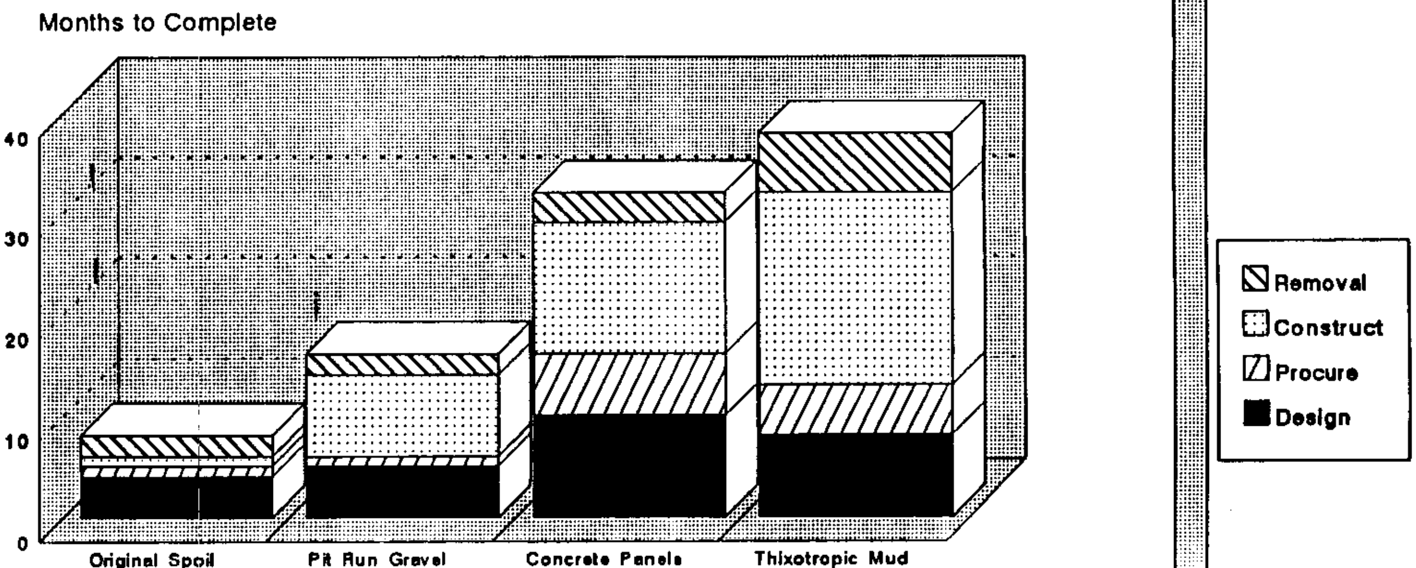
Figure 11. Remediation Times for 1301-N/1325-N.

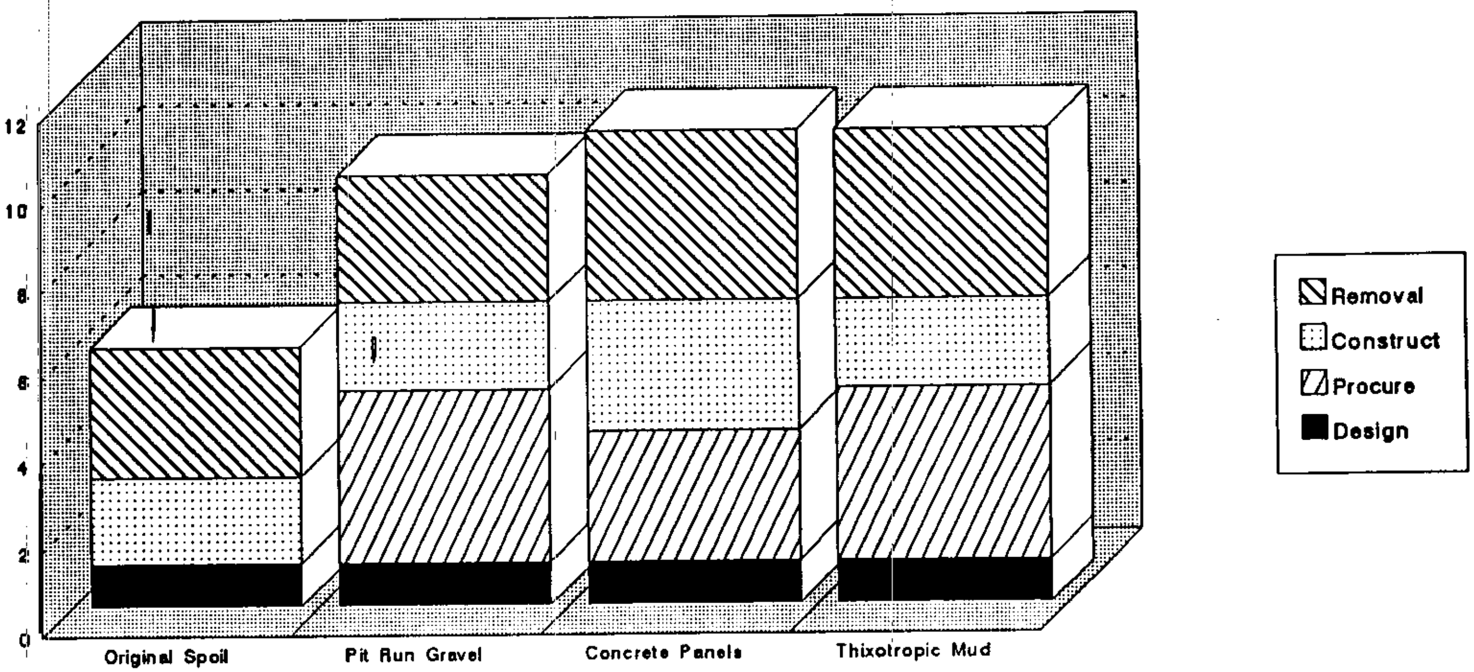



| | Original Spoil | Pit Run Gravel | Concrete Panels | Thixotropic Mud |
|---|---|---|---|---|
| Removal | 2 | 2 | 3 | 6 |
| Construct | 1 | 8 | 13 | 19 |
| Procure | 1 | 1 | 6 | 5 |
| Design | 4 | 5 | 10 | 8 |

Implementation Times Associated With Each Alternative

Industrial Accident/Radiological Exposure Potential Associated with Each Alternative

Discrete Number of Unit Operations




| | Original Spoil | Pit Run Gravel | Concrete Panels | Thixotropic Mud |
|---|---|---|---|---|
| Removal | 3 | 3 | 4 | 4 |
| Construct | 2 | 2 | 3 | 2 |
| Procure | 0 | 4 | 3 | 4 |
| Design | 1 | 1 | 1 | 1 |

Figure 12. Industrial Accident Potential for 1301-N/1325-N.

A direct association can be made between the number of unit operations and the industrial accident/radiological exposure potential realized. Simply put, the more unit operations there are, the greater the opportunity for accidents and/or exposure. On the other hand, elementary operations are easier to control because they have fewer unit operations.

Other criteria are as follows:

- The number of unit operations associated with each phase of every alternative was determined.

- Unit operations were considered for both off-site and on-site activities. In this instance, pit run gravel being loaded elsewhere and trucked to 100 N Area represented 2 unit operations.

- For the purposes of this report, individual operations were not analyzed other than to identify an operation's accident potential.

- Multiple unit operations were assigned to multiple-phase unit operations; for example, placing and removing forms may be represented by two unit operations.

## 6.6 Interpretation of Data

The data summarized in Figure 13 demonstrates that the cover alternative with existing spoil has advantages in the areas of cost, time, and safety. An evaluation of the evaluation criteria provided the following results:

a) From the perspective of placement, the cover with spoil alternative has the fewest opportunities for interruption and is judged to be the simplest cover to install.

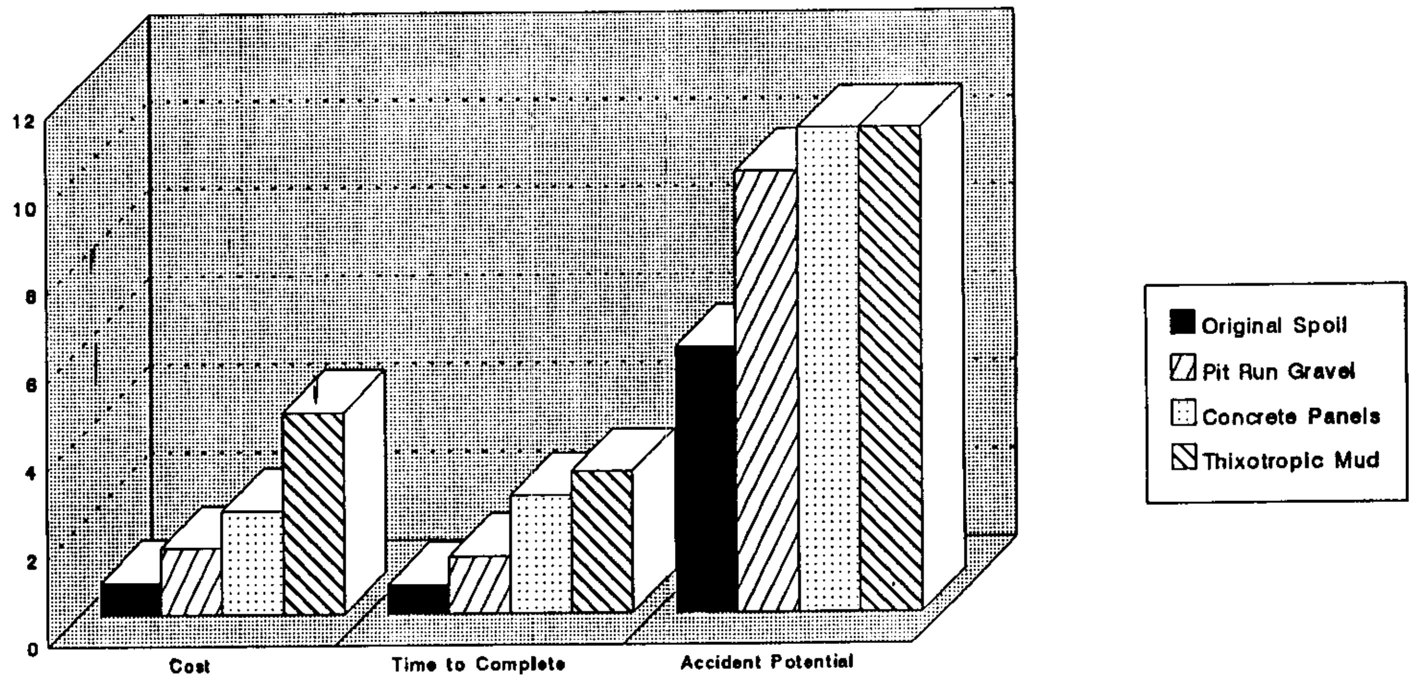
b) Substituting pit-run gravel for original spoil introduces quarry and transportation activities to the process, creating opportunity for problems and complications.

c) The placement of concrete panels or the layering of thixotropic mud creates opportunity for special placement apparatus as well as additional personnel requirements.

In consideration of a through c above, the cover with spoil alternative offers the safest and simplest cover to install and maintain. Therefore, if the skyshine phenomenon is to be abated, existing spoil (or suitable equivalent) should be used to accomplish the shielding activity.

9 1 3 3 0 4 . 2 7 8 3

Figure 13. Remediation Alternative Totals for 1301-N/1325-N.




| | | | |
|---|---|---|---|
| Original Spoil | $ 0.736 | 0.67 | 6 |
| Pit Run Gravel | $ 1.5 | 1.3 | 10 |
| Concrete Panels | $ 2.335 | 2.67 | 11 |
| Thixotropic Mud | $ 4.57 | 3.2 | 11 |

Totals of Cost, Time, and Industrial Accident Potential
Units: Cost in Millions, Time in Years, Industrial Accidents in Potential

# 7.0 IMPLEMENTATION SCHEDULE

## 7.1 No Action Alternative

All the components of the no action alternative are in place and do not require implementation.

## 7.2 Cover Alternative

In implementing the cover alternative, the following four-phase approach should be established.

The first phase would identify the best scheme for the placement of shielding material. An engineering analysis would be performed to determine the best scheme for placement of the shielding material (which should take 60 days to implement). The following objectives should be pursued within the analysis:

1) Minimize dust emissions to the point where an "air permit" would be unnecessary.

2) Reduce opportunities for excessive radioactive exposure.

3) Reduce opportunities for industrial accidents.

4) Preserve the continuity of usefulness in vector and weed control (which the existing concrete panels presently provide).

5) Pursue a shielding placement scheme that does not complicate final removal efforts expected to be performed at a later date, as determined in the *1301-N/1325-N Closure Plan/Corrective Measure Study.*

The second phase should be to develop construction documents. The estimated time to complete this phase is 4 months. During the second phase, the engineering plans and specifications will comprise the bidding package. The following design considerations should be embedded within the project specifications.

1) Design Considerations

- In the interest of convenience, continuity, and cost effectiveness, the alternative chosen for the abatement of skyshine should be consistent with remediation practices planned for other areas of the Hanford Site.
- The shielding design should require little maintenance.
- The construction activities should be phased to accommodate pause periods. During such pause periods construction activities would cease long enough to allow for the collection and evaluation of skyshine reduction data.

If, for instance, it is found that the skyshine phenomenon is adequately reduced after shielding the first third of unit 1301-N, no further abatement activity would be warranted. There is a possibility that the skyshine interim abatement action may be abbreviated or discontinued after partial shielding is completed.

- The grading plan must accommodate run-on/run-off control.
- The design must provide mechanisms for weed and rodent control.
- The design must be compatible with the long-term (i.e., permanent) remediation goals for the skyshine units as determined in the *1301-N/1325-N Closure Plan/Corrective Measure Study*.
- Land surveying practices must adhere to standards which are presented in the *Standard Specifications for Geodetic Control Networks* (Federal Geodetic Control Committee [FGCC] 1984).

2) Related Work: In specifying the interim and final abatements for the skyshine phenomenon the following elements of "related work" should be considered:

- Skyshine units 1301-N and 1325-N should be covered in such a way as to resemble other similar land disposal units (both in appearance and composition) except that the existing concrete panels should be utilized to minimize biotic transport pathways. If similarity is achieved, final remediation for the skyshine units may be accommodated through other work packages that target "similar" units. Exposure rates should be kept As Low As Reasonably Achievable (ALARA).
- Custodial activities (e.g., weed and rodent control) should be combined with similar activities planned for other units.
- 100 N Area environmental restoration projects must not be impeded.

The third phase of the cover alternative should be the execution of the work. The estimated time to complete this phase is 2 months (pursuing of the preferred alternative of native spoil placement). During phase 3, the installation of the shielding layer will be completed. It is suggested that those portions of the 1301-N and 1325-N units that have the highest surface dose rates be started first.

The final project phase should be project acceptance and project close out. The estimated time to complete this phase is 1 month. The following activities must be accomplished during the fourth phase:

1) Site survey control points established.

2) Skyshine phenomenon readings recorded.

3) As-built drawings prepared (complete with certifications).

4) Measurement and payment for services rendered.

5) Area cleaned up and work crews and equipment evacuated.

# 8.0 CONCLUSIONS

The following synopses have been prepared in order to assist DOE/RL in deciding the appropriate course of action for skyshine abatement in order to protect the public prior to implementation of the *1301-N/1325-N Closure Plan/Corrective Measure Study*.

## 8.1 No Action Alternative

The no action alternative may offer the immediate advantages of economy and safety, because skyshine levels along the 100 N Area shoreline are below the DOE public exposure limit. Access restrictions and closure plans would continue without additional capital expenditures. In addition, remediation worker exposure would not be an issue since remediation would not be required.

## 8.2 Cover Alternative

If it is decided that abatement action is justified, then local spoil should be applied as shielding to 1301-N/1325-N to protect the public while closure plans are proposed. Access restrictions and closure plans would continue; however, remediation workers could potentially be exposed to excessive radiation exposure during cover placements. Significant site preparation and health and safety issues would need to be addressed to keep exposures to ALARA.

# 9.0 REFERENCES

Dataquest, 1993, *Cost Reference Guide for Construction Equipment*, Dataquest Inc., San Jose, California.

DOE, 1993a, *Limited Field Investigation Report for the 100-NR-1 Operable Unit*, DOE/RL-93-80, Draft A.

DOE, 1993b, *Radiation Protection of The Public and The Environment*, U.S. Department of Energy, DOE 5400.5, Change 2, January 1, 1993.

DOE, 1994, *Radiation Protection of The Public and The Environment*, U.S. Department of Energy, Richland Operations Office, RLID 5400.5, July 20, 1994.

FGCC, 1984 et. seq., *Standards and Specifications for Geodetic Control Networks*, Federal Geodetic Control Committee, Washington, D.C.

PNL, 1993, *Investigation of Exposure Rates and Radionuclide and Trace Metal Distribution Along the Hanford Reach of the Columbia River*, Battelle Pacific Northwest Laboratory, September 1993.

PNL, 1994, *Hanford Site Environmental Report for Calendar Year 1993*, PNL-9823/UC-602, Battelle Pacific Northwest Laboratory, June 1994.

WCB, 1994, Private Communication, W. C. Borden to A. L. Nellesen, *Transmittal of Radiation Exposure Rate Survey*, September 1994.

WHC, 1991, *1301-N Shoreline Dose Reduction Study*, Westinghouse Hanford Company, WHC-SD-NR-ES-009, Revision 0, December 20, 1991.

WHC, 1994a, *Engineering Study of "1301-N Shoreline Dose Reduction Study," The Skyshine Problem*, WHC-SD-NR-ES-009, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

WHC, 1994b, *Environmental Monitoring Annual Report, CY 1993*, Westinghouse Hanford Company, WHC-EP-0573-2/UC-570, July 1994.

WHC, 1994b, *Runoff Estimates for Trenches 1301-N and 1325-N*, Draft Copy, Westinghouse Hanford Company, Richland, Washington.